# Update on the Development and Construction of the KamLAND 4pi Full-Volume Calibration System

The 4pi Group

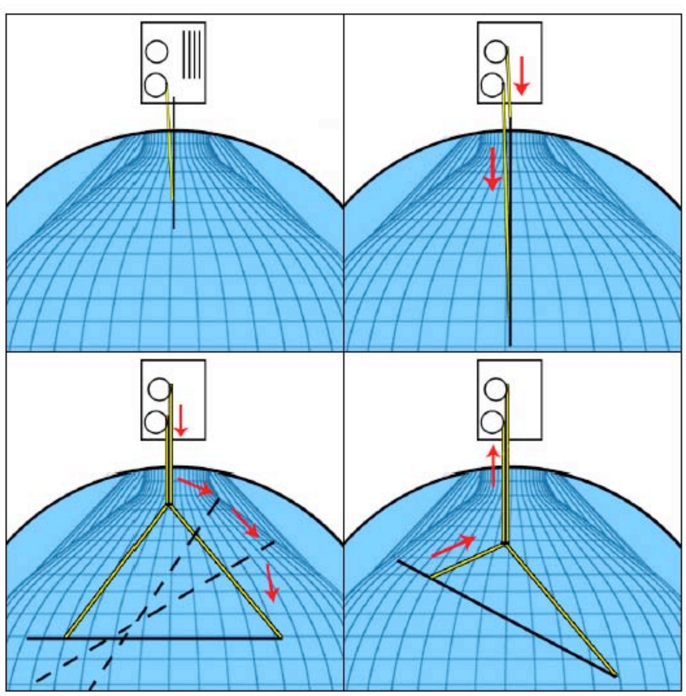
July 6, 2004

## Summary

The 4pi full-volume calibration system for KamLAND is a calibration source manipulator that will allow the accurate placement of calibration inside the fiducial volume . The idea of a calibration pole was prototyped and tested in summer 2003. Construction of the system began in early 2004. The system uses a segmented titanium pole of variable length with a calibration source attached to its end. The pole is assembled inside the glovebox and lowered into the central detector region with two control cables. The system is designed for deployment through the glovebox which provides access to the inner detector region. This new calibration system is currently being assembled and tested at Berkeley. We expect the system to be ready for installation in Fall 2004.

This document gives a brief update on some of the recent modifications and design changes to the system.

For further information see: http://kmheeger.lbl.gov/kamland/4pi/



# I. Mechanical Hardware

**Calibration Pole Deployment system**

The new deployment hardware for the 4pi system is essentially complete. Modifications and the re-design of several parts have delayed the assembly schedule but added significant safety features and generally improved the system. During the assembly in early May both motors suffered from a connection failure. Since then they have been repaired and tested. All cables to the motors, the encoders, and the slip rings, are now keyed to avoid any errors in connecting the cables to the new deployment hardware in the glovebox. A summary of recent hardware modifications and design changes is given below.

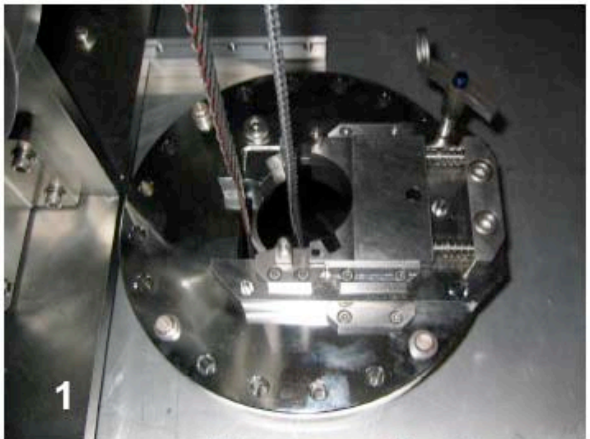
**Pin block**

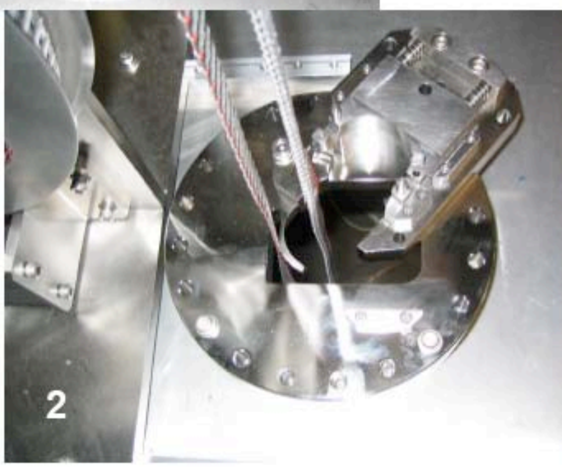
Design and fabrication of the pin block are complete. The pin block has been installed in the mockup glovenbox at Berkeley and is being tested. The re-design of the pin block includes an improved 3-step safety lock for the titanium tube segments and a rotational mechanism for allowing the pivot block to pass through the pin block assembly.

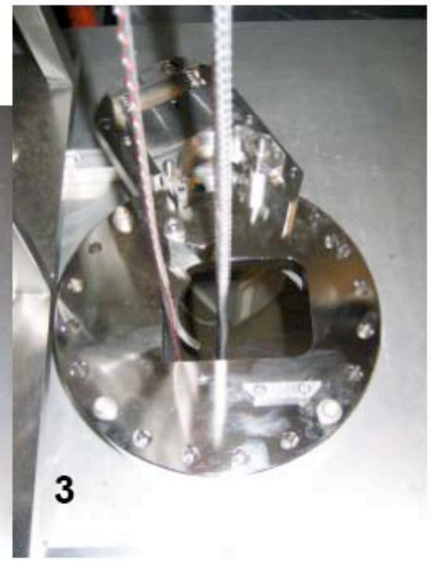
The new pin block is now mounted on a conflat that fits the flange in the existing glovebox. For the full-volume calibration with the 4pi system the conflat with the rotating pin block will be mounted in the glovebox. For regular z-axis deployment the conflat and pin block will be removed and the flange will be covered with a cover plate similar to the one that is in use now.

## The New Pin Block

- mounted on conflat flange
- guides control cables
- rotates to allow pivot block to pass
- provides 3-step safety lock

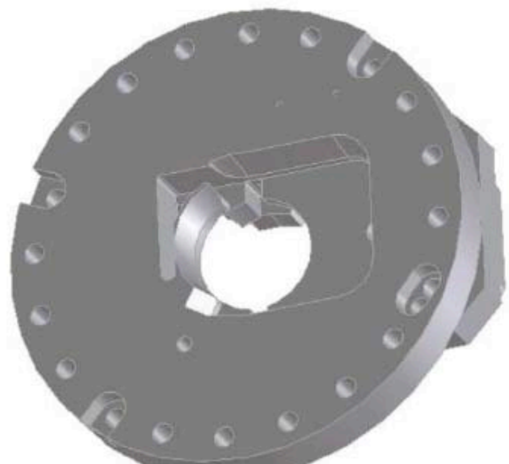



**Parts**

**Bottom of Conflat**



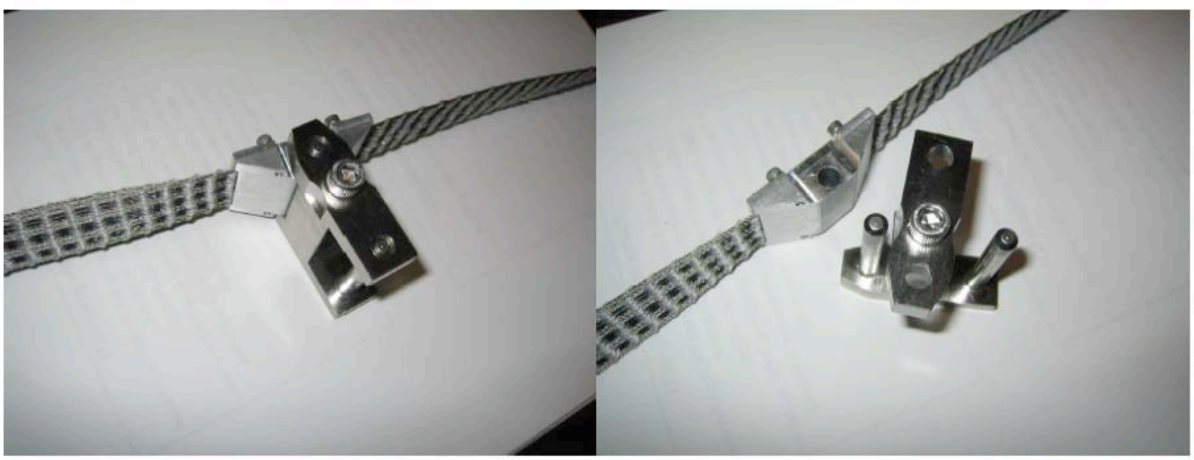
**2. Pivot block**

The pivot block has been redesigned and its final design is still being optimized based on tests with the woven cable, the encoder pulleys. As the key mechanical elemenet for the control of the cablibration pole the design of the pivot block is likely not to be finalized until full-scale tests in the high bay area at Berkeley Lab have been performed. The pivot block now uses a cable clamp to attach to the woven control cable. This eliminates the need for crimping to the stainless steel cables of the control cable. This non-destructive feature allows us to optimize the position of the pivot block during the mechanical tests of the system at Berkeley Lab.

The pivot block consists of two parts: the pivot and the clamp. We envision the clamp to be permamently attached to the cable. The pivot block can be detached from the cable clamp during the assembly/disassembly of the system. We envision that multiple (perhaps 3) cable clamps will be used in the final system so that the pivot block position can be chosen according to the length of the calibration pole to be deployed.

**The New Pivot Block**

- consists of (1) pivot and (2) clamp
- uses cable clamp, no crimping
- adjustable positioning

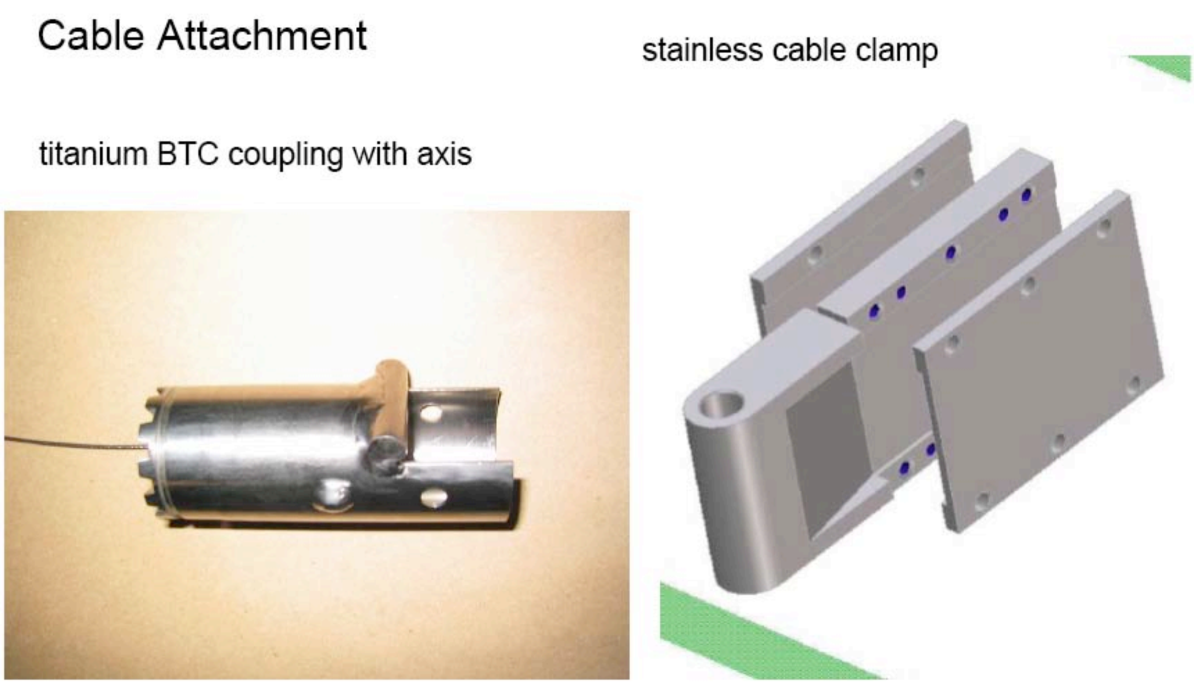


**3. Weight for Z-axis Deployement**

A second z-axis weight assembly for use with the new 4pi system has been built. It is essentially identical in design and dimensions to the existing z-axis weight. We expect it to have identical calibrations properties in terms of shadowing and use.

**4. Cable Attachment**

Titanium cable attachments (shown below on the left) will be permanently attached to the woven control cable. They can be removed and exchanged in case of repair but during normal operations of the system these parts will be stay attached to the cable. These cable attachment pieces provide anchor points for the cables and connect to the calibration pole segments through BTC couplings. We have redesigned the cable attachment parts to make the system as modular as possible. A cable clamp (shown on the right) will connect the woven control cable to the titanium pole couplings (shown on the left). A removable axis will provide the anchor point for the cable clamp. This new design eliminates the need for any load-bearing crimps. The estimated load rating of this design is about 100-150 pounds and exceeds the weight of the calibration pole. Load tests with this new design will be performed.



## II. 4pi Connectors and Cabling Inside Glovebox

We have done extensive research on the availability of connectors in materials that are compatible with the liquid scintillator vapors and are now in the process of assembling power and control cables with the following components. The following table lists the components of the cables to be used inside the glovebox where they are exposed to liquid scintillator vapor. Cables outside the glovebox need to be in compliance with the regular fire and mine code but do not have to withstand scintillator vapor. None of these cables will ever be immersed in liquid scintillator.

| | **Item** | **Description** | **Manufacturer/ Part Number** |
|---|---|---|---|
| **Motor Power** | in glovebox feedthru | stainless steel body, hermetically sealed, gold plated pins, in house modifications | Detoronics DS02H-14S-6P-269 |
| | in glovebox plug | stainless steel body, gold plated sockets, nylon insert (in house) | Amphenol/Matrix MS3456LS14S-6S |
| | Cables | 14 AWG wire, Teflon insulation, silver-plated stranded copper conductor, | |
| | | Teflon helical bundling wrap and Teflon shrink tubing | |
| | out glovebox feedthru | stainless steel body, ceramic insulation, nickel conductors | Ceramaseal 18093-05-W |
| | | | |
| **Motor Feedback** | in and out glovebox feedthrus | stainless steel body, ceramic insulation, gold plated stainless steel pins | Ceramaseal 16802-01-W |
| | in glovebox plugs | PEEK housing, gold-plated sockets | Ceramaseal 16812-01-A |
| | Cables | 20 and 28 AWG wire, Teflon insulation, silver-plated stranded copper conductor, Teflon helical bundling wrap and Teflon shrink tubing | |
| | | | |
| **Slip Ring** | In and out glovebox | stainless steel body, | Ceramaseal |

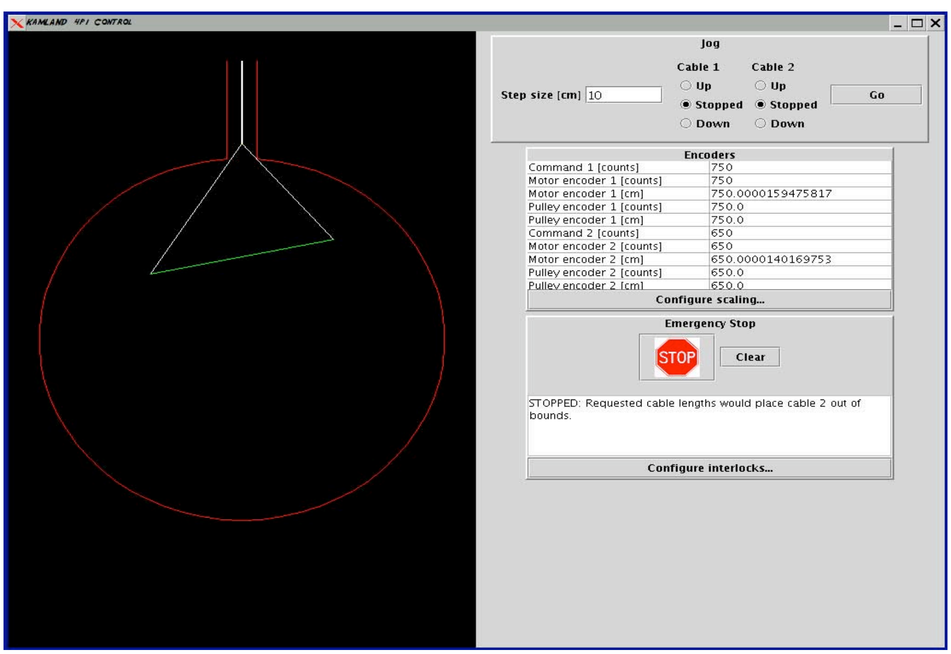
| | | | |
|---|---|---|---|
| | feedthrus | ceramic insulation, gold plated stainless steel pins | 16800-01-W |
| | In glovebox plugs | PEEK housing, gold plated sockets | Ceramaseal 16810-01-A |
| | cables | 22 AWG wire, Teflon insulation, silver-plated stranded copper conductor, Teflon helical bundling wrap and Teflon shrink tubing | |
| | | | |
| **Pulley Encoder** | In and out glovebox feedthrus | stainless steel body, ceramic insulation, gold plated stainless steel pins | Ceramaseal 16801-01-W |
| | In glovebox plugs | PEEK housing, gold plated sockets | Ceramaseal 16811-01-A |
| | cables | 22 AWG wire, Teflon insulation, silver-plated stranded copper conductor, Teflon helical bundling wrap and Teflon shrink tubing | |
| | | | |

## III. Control Software

The control software for the 4pi system is responsible in part for precisely positioning the calibration source at the desired point within the detector while ensuring that no component of the system approaches the fragile balloon as it is being deployed. The software, written in the Java programming language, is divided into two layers that run partially independently from each other, communicating only through a defined protocol. One layer communicates with the control system hardware, while the other provides the program's user interface. This separation provides a measure of protection for the lower-level control program against any errors in the relatively more complex display program.

Currently, the control program is mostly complete and tested, as is the interface between the two layers. It can successfully issue commands to the motor controller, read the values from the encoders attached to the motor and the pulley, and read the ADC to which the pressure transducers will be attached. The machinery is in place to monitor the consistency of the motor encoder and the pressure transducer with the pulley encoder readings, stopping the motion if there is a disagreement or if the reconstructed position of any of the fiducial points on the 4pi hardware approaches a prohibited zone defined near the balloon.

The basic features of the user interface program are also in places, as shown in the screen image below. It includes a display of parameters related to the current position of source as well as a visualization of the configuration of the pole and cables. It still remains as a task to add the ability to edit a number of secondary but necessary parameters, such as the length and weight of the pole. Also, a separate version of the user interface that mimics the current z-axis program is in preparation, for use in routine weekly deployments. It is anticipated that refinements of the interface will be made during the final integration testing of the 4pi system in the high-bay area at LBL.



## IV. Pressure Sensor Tests and Readout

Tests of the pressure sensor units in water have been performed at Berkeley Lab. The pressure sensors show good linearity over a range of 6 m. The projected accuracy is better than 2 cm at a depth of 15 m. Eventually, all pressure sensors to be used in the system and all spares will be tested at Berkeley Lab.

The ADC readout of the pressure sensors is currently being integrated into the 4pi control and monitoring software.

## IV. Outstanding Items Prior to Full-Scale Mechanical Testing at the High-Bay Area at Berkeley Lab

A few items remain to be completed before full-scale testing mechanical testing of the system can commence at Berkeley Lab

| | |
|---|---|
| 1. Complete cabling inside glovebox | ~ 1 week |
| 2. Re-machine feedthroughs for slip rings and encoders. | 1-2 weeks |
| 3. Machine cable clamps for cable attachments. | 1 week |
| 4. Fabricate counter-weighted pole segments. | 2 weeks |

Optional but not necessary for first full-scale deployment tests.

## V. Estimated Schedule and Timeline For Construction and Testing

| | |
|---|---|
| July | - Completion of the mechanical assembly of the 4pi system<br>- Continue to characterize pressure sensors and LEDs |
| August | - Mechanical testing in high-bay area at LBNL<br>- Complete prototyping of instrumentation units |

## VI. Anticipated Expenses and Remaining Costs for the 4pi Project

| | |
|---|---|
| 1. Remaining Construction Costs & Purchases | UC Berkeley, LBNL |
| - new face plate for glovebox | |
| - spare cables and connectors | |
| - spare gloves | |
| - feedthroughs | |
| - misc smaller items | |
| | |
| 2. Background counting at Berkeley Lab | LBNL NSD |
| - dry testing | |
| - testing of LS soak samples | |
| | |
| 3. Materials Testing at Mozumi | |
| - Supplies for background counting | |
| - Spectrometer tests | |
| | |
| 4. Rigging and lifting costs for high-bay testing | LBNL |
| | |
| 5. FedEx shipping cost to Japan | UC Berkeley |
| | |
| 6. Travel of RCNS personnel to Berkeley for review and testing | RCNS |
| - Koga | |
| - Mitsui | |
| +others | |
| | |
| 7. Travel of UA personnel to Berkeley for review and testing | UA |
| - Classen | |
| - Yakushev | |
| - Piepke | |
| | |
| 8. Travel of TUNL personnel to Berkeley for review and testing | TUNL |
| - Nakamura | |
| | |
| 9. Travel of LBNL personnel to Mozumi for installation and deployment | |
| - Syversrud | UC Berkeley |
| - Franck | UC Berkeley |
| - Heeger | LBNL PD |
| - Gray | UC Berkeley |
| - Berger | LBNL NSD |
| - Steiner | LBNL PD |
| - Freedman | UC/LBNL |